A geoneutrino experiment at DUSEL?

LOI# 71

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Outline

- Introduction to geoneutrinos
- A DUSEL geoneutrino experiment?

Mantle convection

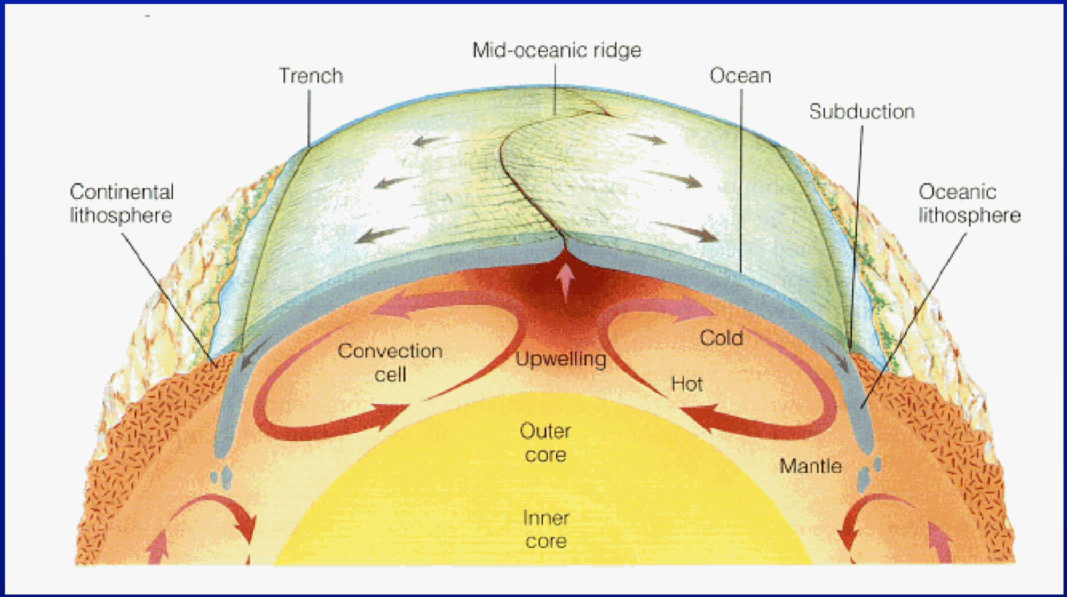


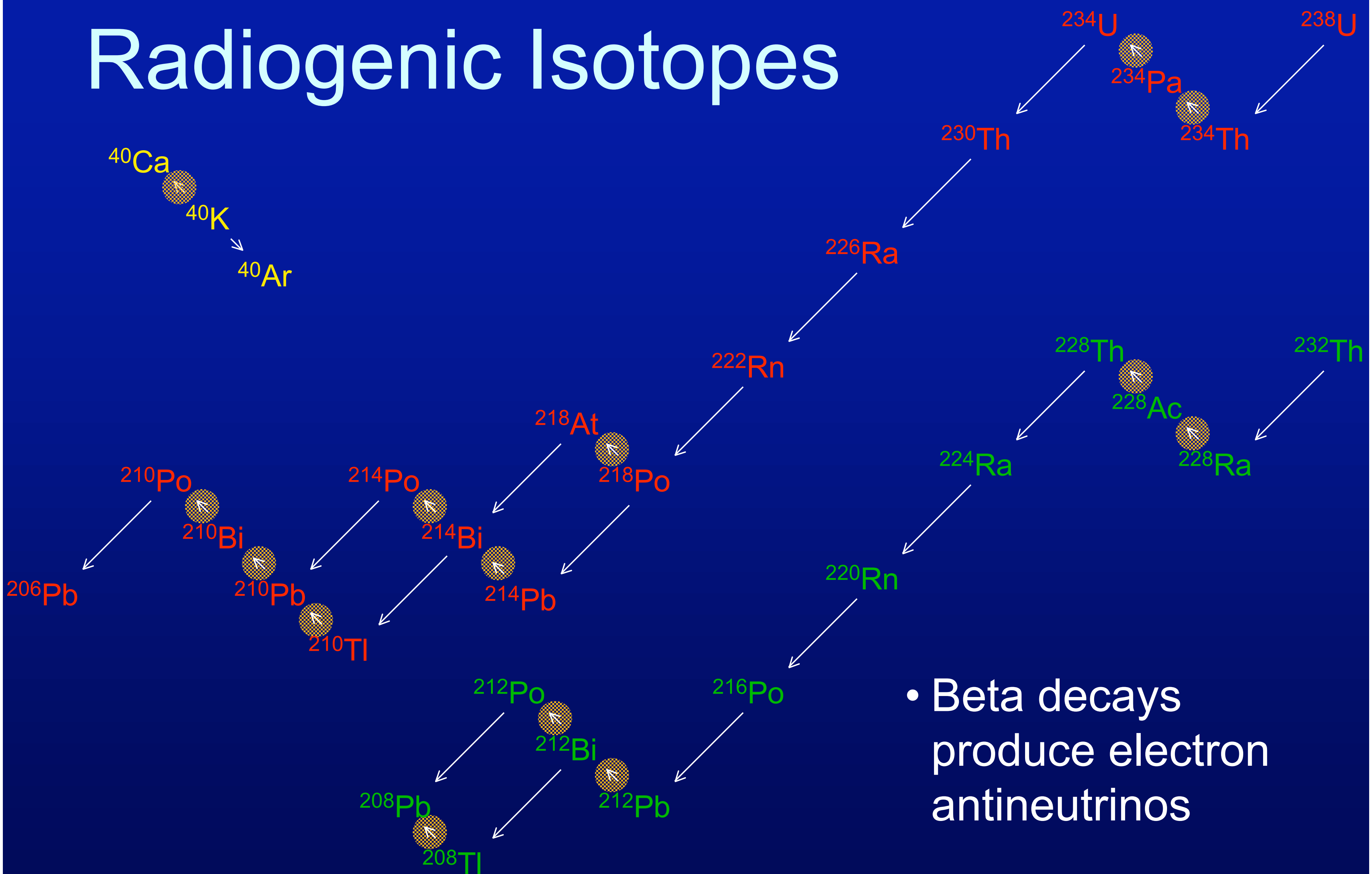
Image: http://www.dstu.univ-montp2.fr/PERSO/bokelmann/convection.gif

- Oceanic crust is renewed at mid-ocean ridges and recycled at trenches.
- This is driven by mantle convection which causes plate tectonics and earthquakes.
- It is thought that this convection is powered by radiogenic heat produced in the mantle.

Earth's heat flow

- Total heat flow is 44±1TW (87mW/m2), or 31±1TW (61mW/m2) according to more recent evaluation of same data.
- Based on chondritic meteorite measurements the U, Th, and K concentrations in the Bulk Silicate Earth (BSE) results in heat production of 8TW, 8TW, and 3TW, respectively, totaling 19TW.
- Models of mantle convection suggest that the radiogenic heat production rate should be a large fraction of the measured heat flow.
- Problem with
  - Mantle convection model?
  - Total heat flow measured?
  - Estimated amount of radiogenic heat production rate?
- Geoneutrinos can serve as a cross-check of the radiogenic heat production.

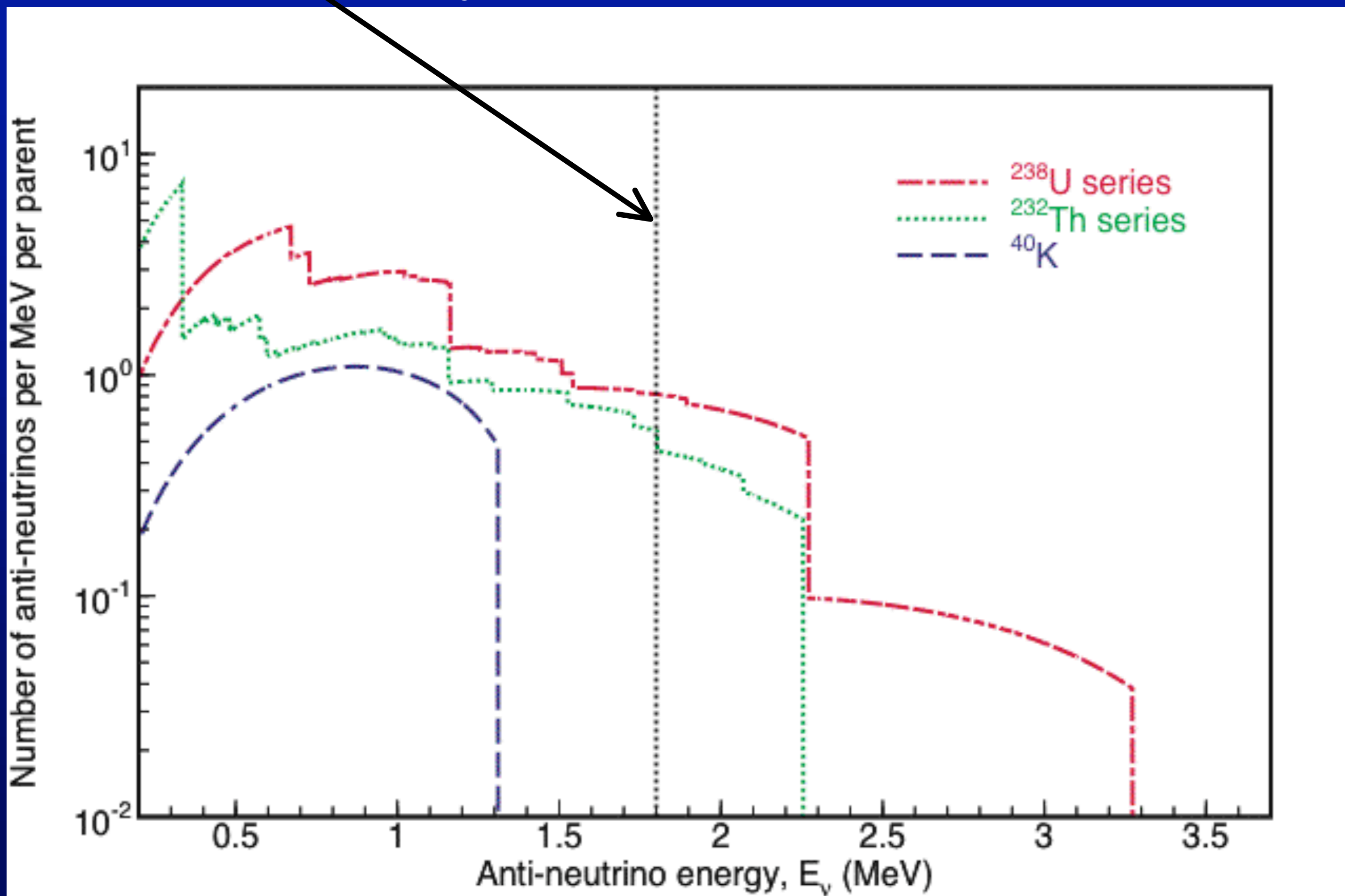
Radiogenic Isotopes



- Beta decays produce electron antineutrinos

Geoneutrino Signal

Proton inverse beta decay threshold



Recent results from KamLAND

- From March, 2002 to October, 2004.
- 749.1±0.5 day of total live-time.
- $(3.46 \pm 0.17) \times 10^{31}$ target protons, 5m radius fiducial volume.
- 0.687±0.007 of the total efficiency for geoneutrino detection.
- Expect 14.8 ± 0.7 ^{238}U geoneutrinos and 3.9 ± 0.2 ^{232}Th geoneutrinos.
- 152 candidate events
- 127±13 background events.

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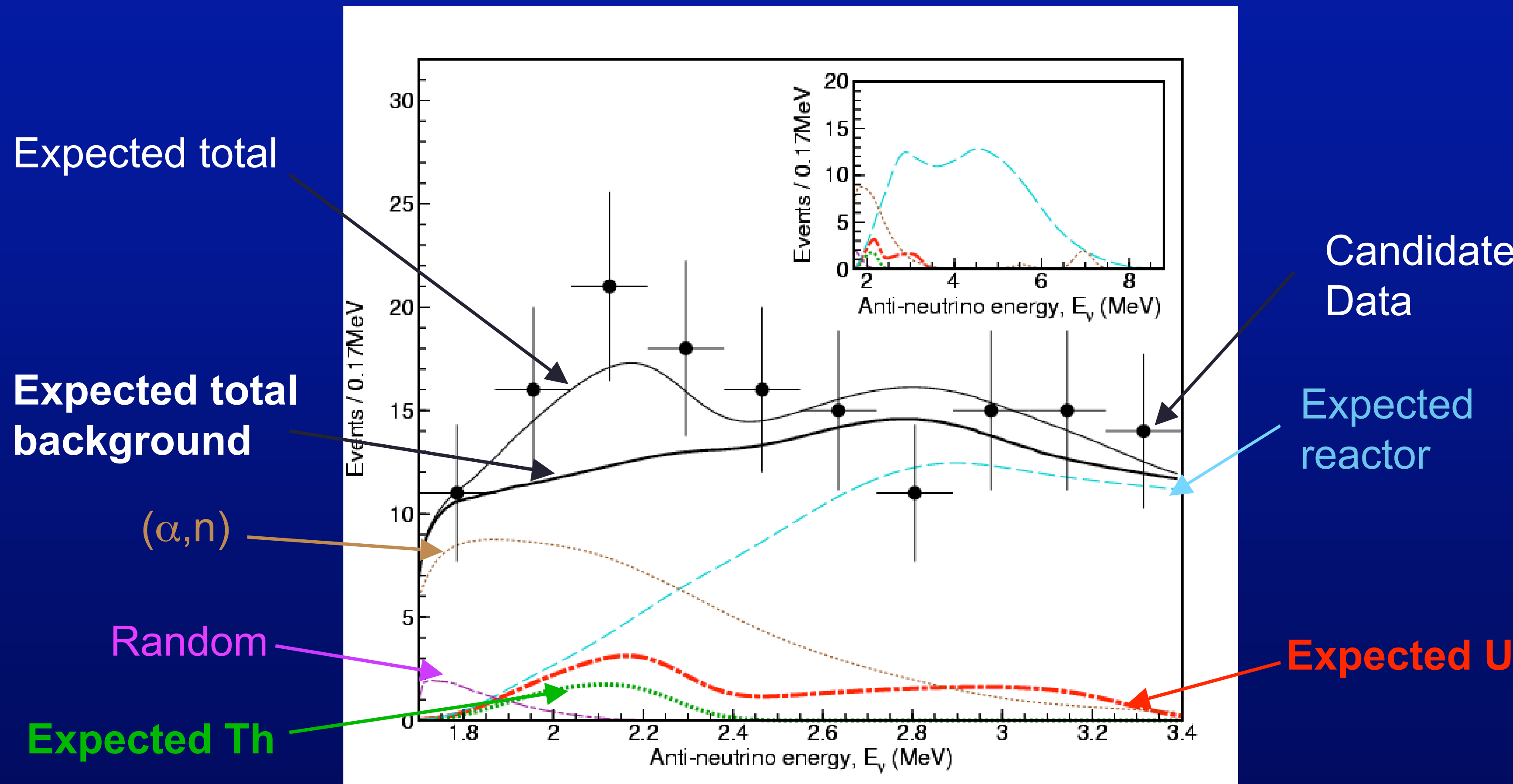
Geoneutrino Candidate Energy Distribution



•The reactor background is irreducible

Georeactor

- It has been hypothesized that a blob of uranium is located at the center of the Earth.
- This could then form a natural nuclear reactor producing up to 6TW of heat, powering the Earths dynamo.
- This could explain the observed anomaly in the $^3He/^4He$ ratio.
- The only way to test this hypothesis directly is to observe the neutrinos produced by this reactor.

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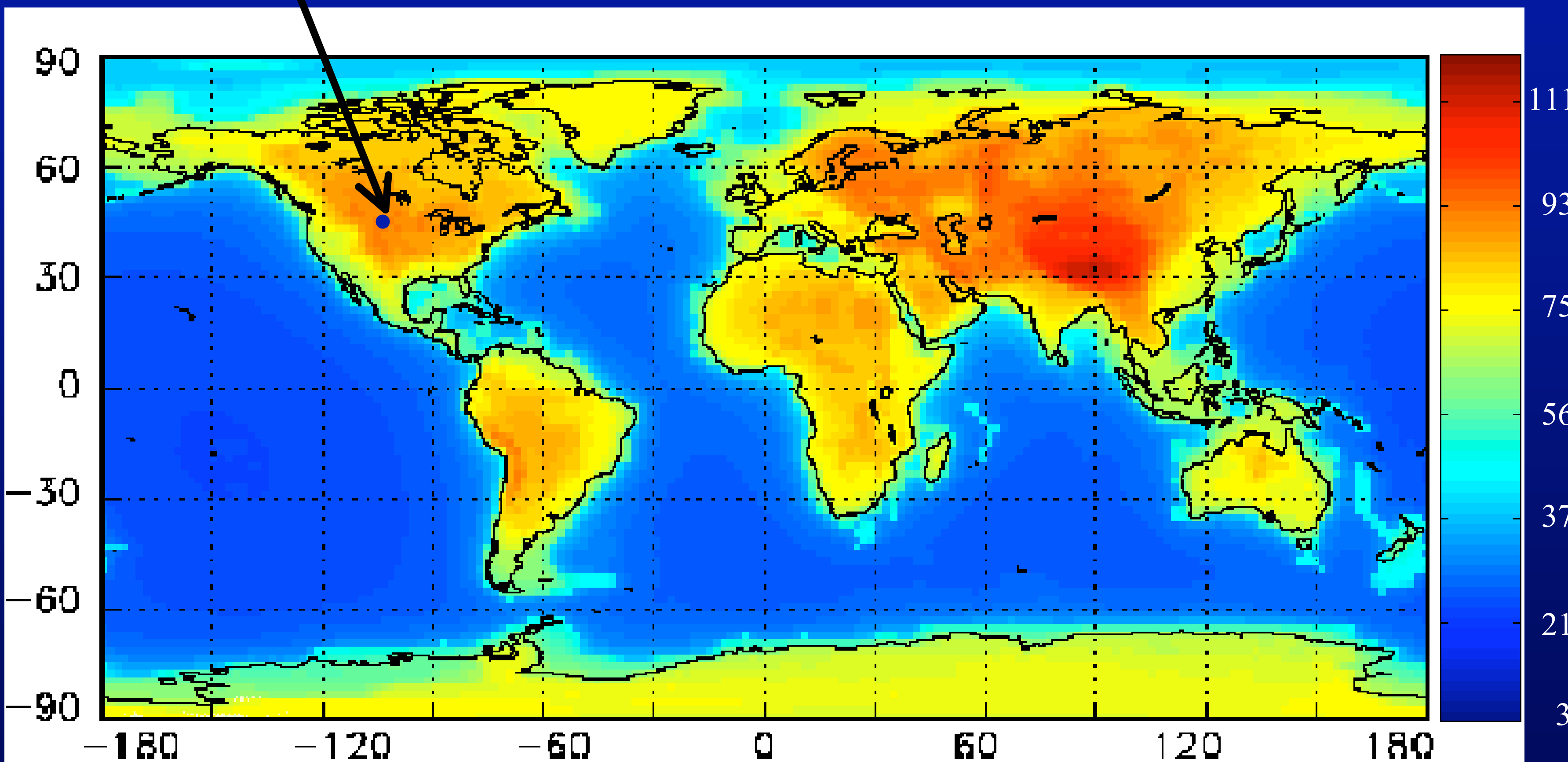
Geoneutrino flux

Homestake: geoneutrino flux 50% larger than at KamLAND

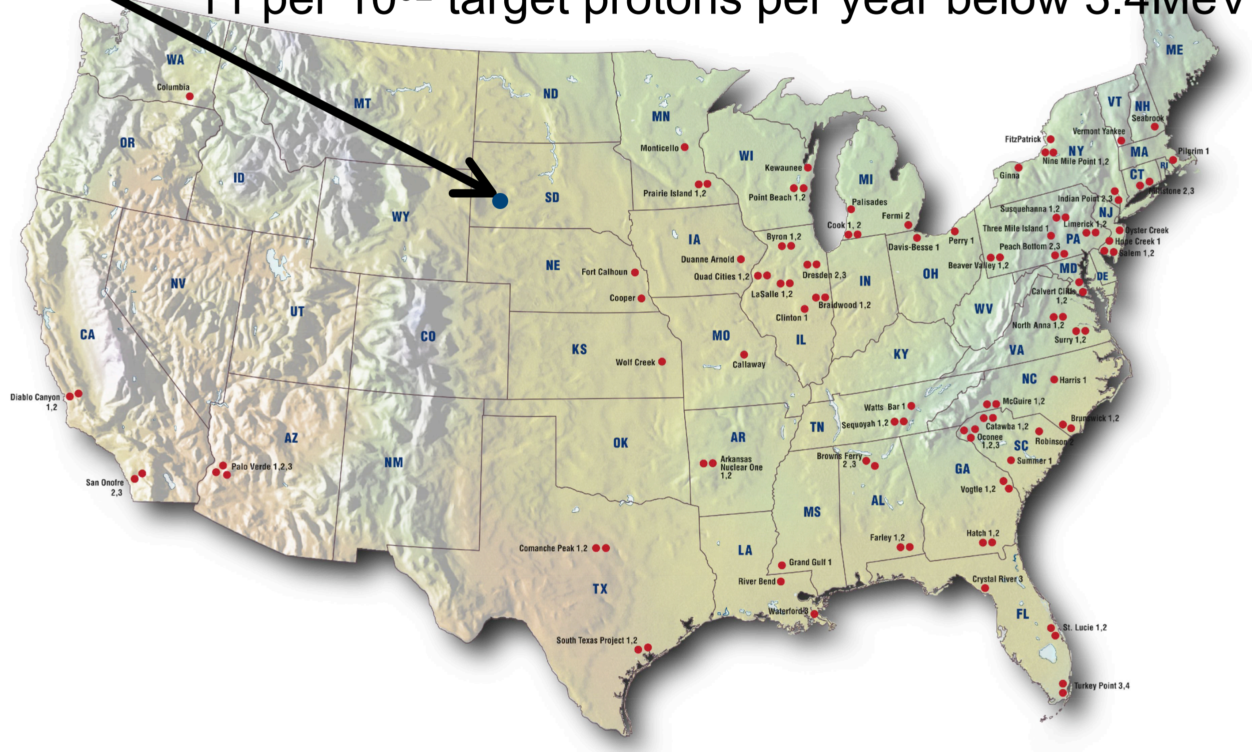


•www.fe.infn.it/~fiorenti

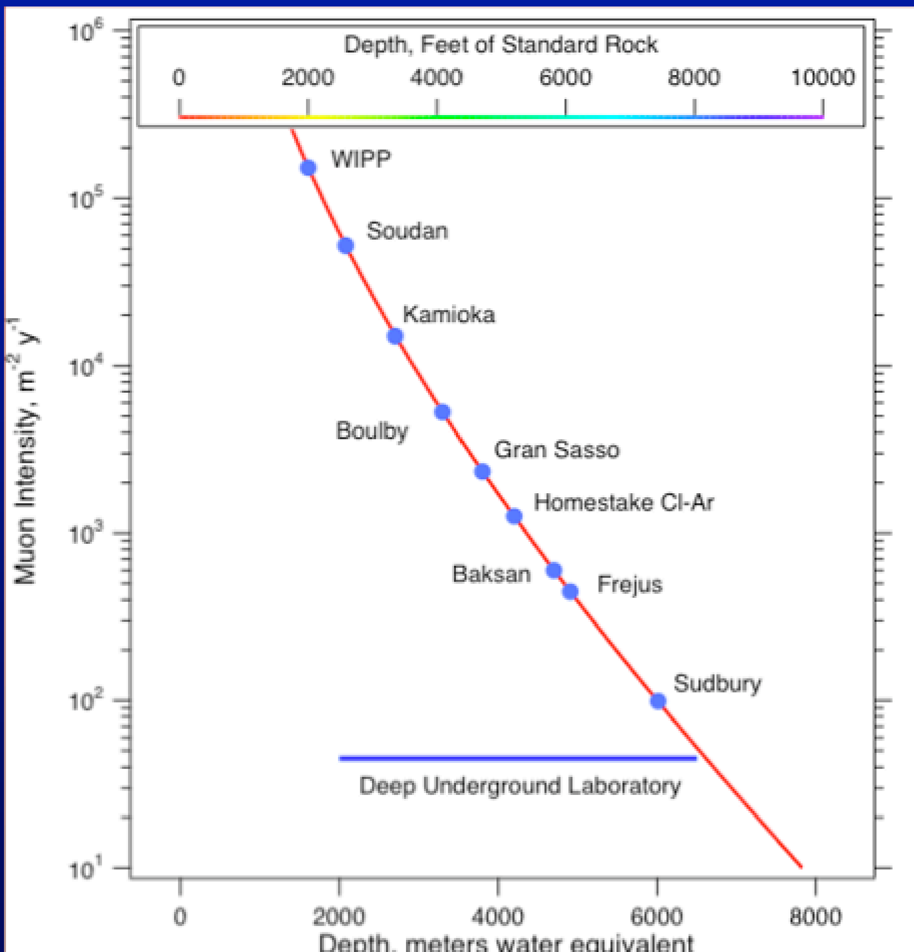
Reactor Background

Homestake: reactor background ~7% of KamLANDs

11 per 10^{32} target protons per year below 3.4MeV



Other backgrounds

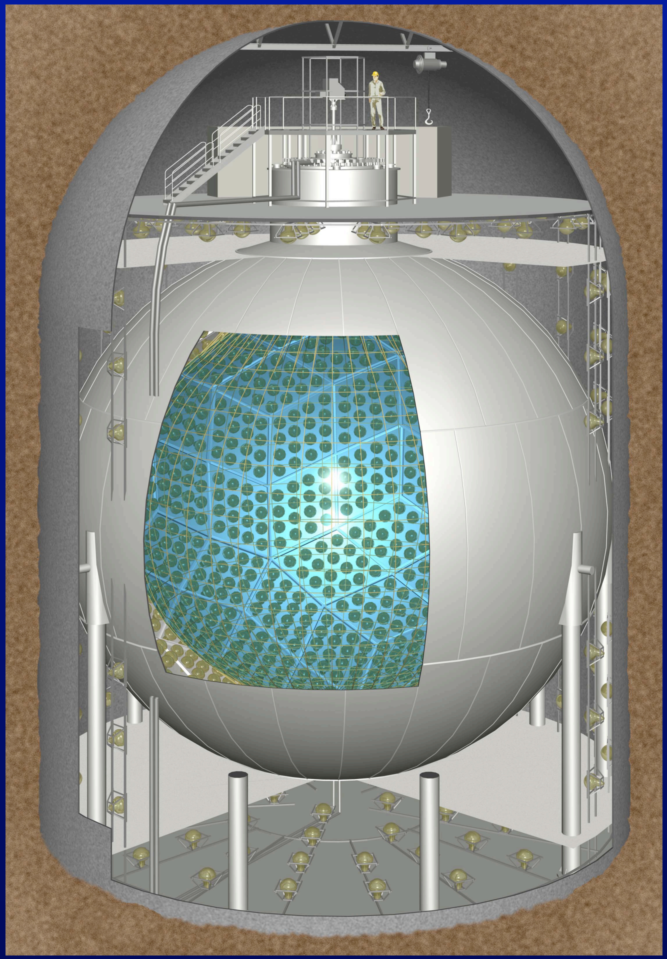


- Necessary U, Th, and Rn concentrations similar to KamLAND.
- Muon flux at 4850 lab is ~30 times less than Kamioka.
- Cosmic background at KamLAND is small, but muon veto causes significant inefficiency.

Detector Requirements

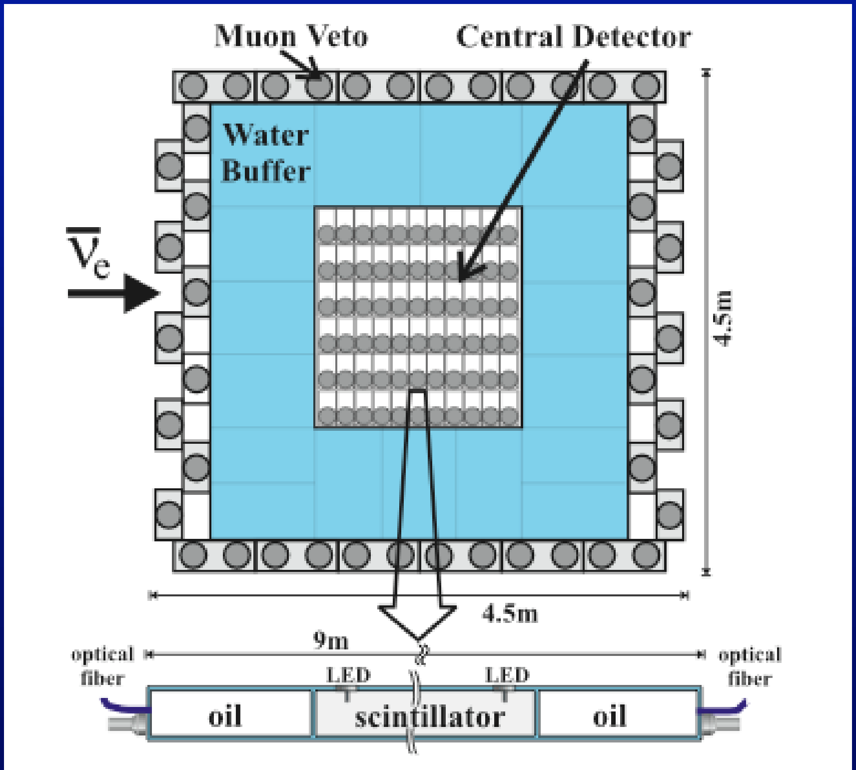
- Expected geoneutrino flux has:
  - 9% error due to neutrino oscillations
  - 7% error due to global crustal variation
  - 3% error due to local crustal variation (at KamLAND)
- Should attempt to make a ~10% measurement of the geoneutrino flux, this requires exposure of 2.3×10^{32} proton years.
- ~2-3 year measurement with KamLAND sized detector.
- To observe a 6TW reactor at the Earths core at 3σ would require exposure of 0.8×10^{32} proton years

KamLAND style detector



- 1kton liquid scintillator.
- ~20m diameter sphere.
- Monolithic:
  - Lower radioactive backgrounds
  - Fully contained events

Palo Verde style detector



- Palo Verde ~11tons liquid scintillator.
- Needs to be ~100 times larger (~4.5 times each dim.).
- Could be rearranged to meet cavity shape.
- Modular:
  - Maybe easier to install
  - Could be moved?

Conclusions

- Can determine the continental crust U and Th content with ~10% error.
- Location in center of a continent allows better estimate of expected geoneutrino flux.
- Could observe a natural reactor at the Earths core.
- A ~1kton detector is the ideal size. This could be located in the Davis cavity on the 4850' level.